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Emílio Bròguеira Dias et Jorge Fernandes Alves

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Ports, policies and interventions in ports in Portugal - 20th Century

Emílio Brògueira Dias
Jorge Fernandes Alves

Traditional ports connected to sailing ships underwent, over the last century, deep changes in their infrastructures, in order to adapt to new conditions in international navigation routes. This process, usually designated as the "ports' revolution," was, rather, a process of continuous adaptation, which was the only way to respond to technological innovation.

In general, large passenger and commercial vessels were selective with ports, requiring large, deepwater ports providing the appropriate infrastructures of support. At the beginning of the twentieth century, the age of "natural harbors" came to an end, substituted by the "age of artificial harbors." Although many traditional ports continued their operations, they were submitted to substantial and continuous changes, in order to be included in the itineraries of large companies and to operate as intermediate stops for passenger transport and foreign trade.

Meanwhile, the world trade evolved in view of the new standards that resulted from the industrial revolution. But by the second half of the twentieth century, the transport of passengers fell abruptly, superseded by the competition of airlines. In the field of cargo transports, a downward trend occured in the transport of bulk raw materials, with primary products losing ground when manufactured high value added goods increased, transported in unitized cargos. Then, containers became a fundamental element, together with roll-on roll-off transport. These solutions, closely connected to land, road or rail transport, using multimodal logistics solutions, hired "as a package," are organized in long-haul routes, and gathered in a direct delivery system. More, in the energy field, the networks of oil and gas pipelines have reduced the importance of maritime transport, although new uses for shipping have emerged, such as for natural gas.

Maritime transport has, therefore, adopted new configurations, and ports are required to accompany these developments, taking part to the rationalization of transport networks, to prevent their falling into disuse. Because of the ascendancy of the market, it became crucial to decide on which ports to invest, how to do it, and to which extent. In other words, what port policy should be adopted in view of the port operation conditions and its level of integration in transport routes? In this way, the areas of expertise indispensable for the operation of ports were

extended considerably, touching multiple fields of knowledge, in order to promote a multi-disciplinary understanding and integrate new technologies. Thus, it became necessary to consider port operations in a wider context, integrated to logistics platforms, weighing up their impact in economic and territorial terms.

As a coastal country with an important and spread overseas empire that only came to an end after the political revolution of April 25, 1974, Portugal underwent the drama of port modernization with great difficulty, always with a feeling of "being behind the times." However, the "port revolution" in Portugal represented a significant technical and financial effort, taking into account its subjacent economic weakness. Some interventions were great achievements in Portuguese engineering, as it can be easily seen in the works performed in the ports of Lisbon, Leixões and Sines, that promoted port solutions on the Atlantic coastline. The network of fishing harbours along the coast should also be mentioned, helping highly traditional activities, and affected by the recent emergence of marinas and recreational ports.

Main lines of port interventions

Broadly speaking, technical interventions on port areas focus on a few but decisive variables: water depth, docks installations, embankments and warehouses, loading and unloading equipment, communications network to the surrounding area, and commercial devices that enhance (or not) the respective ports.

Figure 1. Main Portuguese Ports
Source: APP - Portuguese Ports Association, Mário Rodrigues

These were the types of interventions that took place, in general, in the main Portuguese ports, although their scale varied greatly from one port to another. From an engineering perspective, several constructions of moles extending deep into the water should be noted, sometimes after several attempts, given the almost insurmountable difficulties, along the western coastline of Portugal, known

for its rough seas. A series of problems that required ingenious solutions in several ports, mostly artificial, such as Leixões and Sines: protection from sea waves, providing calm waters in interior basins, dealing with the threat of waves and currents in port approach channels and preventing silting.

Naturally, the extensive Portuguese coastline allowed the creation of numerous sea ports, but economy and common sense determined that investments would have to be made selectively, following policy options, though limited by natural and socio-historical factors. In this way, the main efforts always tended towards focusing on two major ports, coincident with the two economic centers –Lisbon and Porto, although occasionally including other ports of regional importance. It was only when economic planning –using the "development plan" formula– sought to tackle asymmetries and promote more harmonious development, that a few regional ports increased in importance. As a consequence, a new artificial port was created, for large vessels and to be associated to an industrial center, still to be built. This is what happened in Sines, during the 1970s.

Thus, taking into account the number of the operations performed, four lines of intervention in ports, that took place during the twentieth century in Portugal, can be drafted:

1. Small improvements in provincial ports, mainly connected to fishing and coastal vessels, some of which were later enlarged for general operations related to exports (Viana, Aveiro, Setúbal, Figueira da Foz);
2. Deepening works in traditional ports connected to ocean-going vessels, as was the case in the port of Lisbon;
3. Construction of major artificial ports, most importantly Leixões (this port had served as a port of refuge during the nineteenth century) and Sines, both primarily planned for large-scale traffic of heavy goods, but with various capabilities;
4. The recent adaptation of former fishing and coastal service harbors for leisure purposes, through the construction of marinas, which has become a common form of promoting tourism; this phenomenon began to take place in ports in the Algarve but also in some others along the Western coastline.

Ports are not just works of engineering, but also require management, which implies collecting revenue and providing services, as well as planning the adaptation to changes, and responding to new technological and economic demands. Managing the ports was a complex affair, and for many years reported directly to the central government. Indeed, management solutions successfully articulating public interest and private sector or local participation have always proven difficult.

According to a law dated March 3, 1907, the port of Lisbon came under autonomous management, under the designation *Administração do Porto de Lisboa*, while "autonomous commissions" were established for the other ports. The management model for the port of Lisbon revealed itself to be more advantageous. That is why soon afterwards, the "ports law" (Decree-Law nr. 12757, dated December 2, 1926) applied that model to other situations. Under the terms of

that law, ports were classified according to four categories, with 1st class ports (that acted as ports of call along major navigation routes and important internal communication networks, dealing with a high level of cargo or passenger traffic) remaining exclusively under State control. Only four 1st class ports, two in mainland Portugal and two in the islands –Lisbon, Douro-Leixões, Funchal and Ponta Delgada–adopted the Lisbon management model, and it was almost only in these ports that major works took place. For the remaining categories, state participation would be limited, to be supplemented by revenue generated by local taxes. Some legislation issued during the following years –1927 (Decrees 14718 and 14782) and 1928 (Decree 15644)– revised certain details of the legal framework that was to remain in force for a number of years. In 1949, the standards for port management were readjusted with a new framework law ("Port Operations Law", Law nr. 2035, dated July 30th).

Soon after, a Decree-Law nr. 9/74, dated January 14, 1950, provided new stipulations, though without making any essential changes, whereby the "autonomous commissions" would manage and operate ports, preparing and equipping them, planning and performing internal works, as well as the maintenance and repair of maritime and land infrastructures. In as far as concerned mainland Portugal, there were "autonomous commissions" for the "Ports of the North" (Viana, Póvoa de Varzim and Vila do Conde), Aveiro, Figueira da Foz, the "Ports of the Center" (Nazaré, Peniche, Ericeira), Setúbal, in addition to the "Ports of the Western Algarve" (Baleeira, Lagos and Portimão), and the "Ports of the Eastern Algarve" (between Faro and Vila Real de Santo António). The "management" model was in force in the ports of Douro-Leixões and Lisbon, (according to the 1948 law, Decrees nr. 36977 and 36976, both dated July 20th) and, later on, was also adopted in Sines (according to Law-Decree nr. 508/77, dated December 14, 1977).

With regard to port interventions, the National Dictatorship governments (1926-1933) moved away from the mere discussions typically held during the 1st Republic (1910-1926), actually executing works at the location, revealing a degree of decision-making capacity, especially through the actions of Minister Antunes Guimarães (former head of the port of Leixões), who started and/or prepared the execution of some interventions.

The proposed works received initial funding following the approval of a government loan of 300 million PTE (Decree nr. 17047, dated July 29, 1929), which was followed by an initial allocation of funds to various ports, in order to finance existing projects. Shortly afterwards, an action plan was elaborated (Decree nr. 17421, dated September 30, 1929), which, aggregating what were previously loose proposals, constituted the starting point for the "port plan." The works defined were aimed principally at the ports considered of national importance –Lisbon and Leixões, and ports of regional importance– Setúbal, Vila Real de Santo António, Aveiro, Viana do Castelo and Figueira da Foz. The plan, however, originally forecast to be concluded in 1932, lagged behind in certain ports.

There was further funding in 1935, but in some cases the plan was only completed in 1949. At any rate, significant interventions date back to this period, such as the construction of quays and embankments in the port of Lisbon, be-

tween Santa Apolónia and Poço do Bispo, the commercial port (dock nr. 1) in Leixões, the construction of the North mole and the initial works on the South mole in Póvoa de Varzim, the access improvement in Aveiro and Figueira da Foz, improvements regarding commercial and fishing services in Aveiro, the access improvement in Faro and Olhão, commercial adaptation works in Vila Real de Santo António, and shelter and mooring in Funchal and Ponta Delgada. A permanent government agency to carry out dredging was also created.

Towards the end of World War II, Stage 2 of the "port plan" was put into motion, through Decree-Law 33922, dated September 5, 1944, with forecast costs about over 450 million PTE, including improvements in several national ports (except Lisbon), although only 50% of the plan was executed. The public works were geared towards "improving access to ports and creating the shelter indispensable for navigation, commercial traffic and maritime activities in general," supplemented by internal works for mooring and commercial, in order to increase the value of industrial and fishing centers (which was the case in Setúbal, Faro, Olhão, Portimão and Vila Real de Santo António, Sines, Figueira da Foz and Aveiro). At that time, the offshore transshipment of goods from vessels to barges was still commonplace, since larger vessels were unable to reach the docks, and even some cod-fishing vessels were forced to unload their cargoes in more developed ports (Leixões) before heading to their final destination (Aveiro).

The port of Lisbon, however, was considered separately, and was the object of a special plan (Decree-Law 35716, dated June 24, 1946), which provided for interventions with a budgeted value of approximately 650 million PTE, to be applied to a number of works between 1946 and 1955.

The next step taken was including port works in various Development Plans (1953-1974), including those already provided for in previous projects, and promoting a number of large-scale interventions in the main ports, particularly those that were lagging behind in Lisbon and Leixões. In other words, implementation was slow in relation to the quick elaboration of projects, largely due to the lack of available funds. But the project for the new port of Sines owes its existence to the planning policy of this period. Aiming to promote the urban and industrial development of the area and the surrounding region – the Alentejo (it should be noted that the Alqueva project was also proposed within this scope), the first works were awarded in 1973, but were only executed during the period following the revolution.

Other more recent actions followed, now within the scope of the structural reforms leading towards full integration into the European Economic Community, focusing on the creation of a number of logistics platforms in the main ports, improving equipment, promoting better traffic management (using telemetry for the implementation of VTS and other systems), creating accesses for intermodal modes of transport, along with repair work on interior spaces and surroundings. It was in this spirit that further legislation was issued, with Decree-Law nr. 348/86, dated October 16, which applied the "Framework Law for the National Port System," introducing principles of administrative and financial autonomy and business management in port authorities, enabling their transformation into

public institutions, while establishing new supervisory bodies. This last aspect was resumed with further legislation (Decree-Laws nr. 319/93 and nr. 323/93, both dated September 21).

EU funds –the Cohesion Fund (for large-scale projects in Leixões, Lisbon, Setúbal and Sines) and the European Regional Development Fund (ERDF), for small and medium-sized ports, have co-funded the recent policies of improvement and consolidation of Portuguese ports. Between 1994 and 1999, EU funding reached a total value of 43 400 million PTE, which, in addition to Portuguese funding, corresponded to a total volume of 60 000 million PTE, for the implementation of the approximately twenty projects submitted.

If, throughout the century, the ports of Lisbon, Sines and Leixões, and, to a lesser degree, the ports of Madeira (Funchal) and the Azores (Ponta Delgada), due to their international relevance, were given greater attention, receiving the majority of the investments, other ports, considered second or third class, saw also the execution of improvement works, increasing their operational safety and/or operational capacities, thus leading to an increase in traffic in terms of the number of vessels and quantity of cargo. This is especially the case with the ports of Aveiro and Setúbal, that outgrew their character of fishing harbors in the 1960s to become loading / unloading ports for other types of commodities, related to handling large-scale industrial cargo, and, to a lesser extent, ports such Viana, Coímbra and Vila Real de Santo Antonio, as well as others of reduced importance.

As it is not possible to develop all the ports and respective interventions, we will concentrate on those that we consider the most relevant in Portuguese port facilities on the mainland.

The Port of Leixões

Leixões started off as a port of refuge, ancillary to the port of Douro, built between 1884 and 1892, using a pair of moles starting from the coast and supported by the rocks (*leixões*) that surrounded the estuary of the River Leça, according to the project by Afonso Nogueira Soares. In order to guarantee the connection between Douro and Leixões, which were meant to operate interconnected, multiple solutions were considered, with some calling for a canal, soon abandoned, others proposing a railroad link along the coastline, while other experts advised that a commercial port should be built there, given the fact that it was technically and economically impossible to transform the Douro port in a way that would meet the requirements of modern navigation.

The evolution of the port of Leixoes, during the course of the twentieth century, was a break from nineteenth century concepts, although contrary to the desires of the established power in the city of Porto, with vested interests in Ribeira. On the one hand, the commercial potential of the port of Leixões became so evident that, even before the moles were completed, vessels were entering the port in order to load and unload goods, without any type of structural support, thus

calling for its transformation into a commercial port. Then, in view of this option, the concept of the Douro-Leixões system lost importance, remaining merely a political problem, which was to disappear entirely with the elapsing of time.

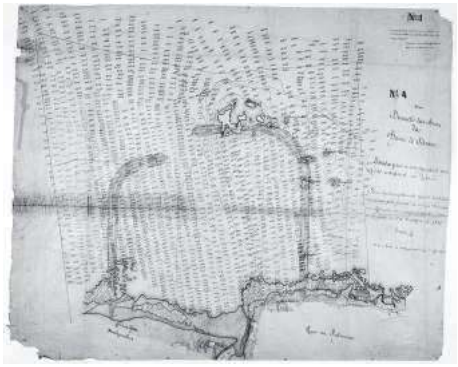

Figure 2. Port of Leixões construction study 1880
Source: Port of Leixões Archive

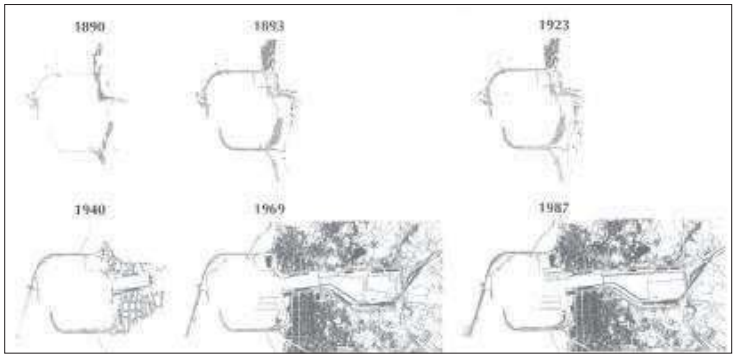

Figure 3. Port of Leixões evolution
Source: Port of Leixões Archive

The transformation of the port of Leixões into a commercial port was based on a project by Adolfo Loureiro and Antonio Santos Viegas, dating from 1907. They planned the construction of three interior docks, taking advantage of the characteristics of the Leça valley. This project set out the layout for the port of Leixoes, although it was successively redesigned (projects by Assunção in 1912, and Machado Junior, in 1915). The works took place slowly and by stages, and were truly a challenge of man versus nature, also due to the difficult conditions caused by ocean currents, causing multiple failures in the jetties, and successive reconstruction work. Indeed, it was a matter of bringing the sea inland, for which purpose the rocky valley of the River Leça was excavated.

At the turn of the century, the major works were aimed at rebuilding the moles of the refuge port, repeatedly destroyed by the force of the sea, causing

serious difficulties for the concessionaire –the *Companhia das Docas e Caminhos de Ferro Peninsulares*, which, with the advent of the Republic, was replaced by the *Junta Autónoma das Obras da Cidade*. On this entity's proposal, legislation was approved, establishing the works that needed to be done (project by engineer Henrique Carvalho de Assunção, a variation on the Adolfo Loureiro project) and put them under the responsibility of the then called *Junta Autónoma das Instalações Marítimas do Porto (Douro-Leixões)*.

During a difficult historical period (First World War), the first step towards executing the project was taken, and adapted the existing structure for commercial services. It took advantage of the quay on the interior South mole of the refuge port, making it "moorable for high tonnage vessels." Adjacent to the inner wall of the mole, a rectangular prism of artificial blocks was built, at a depth of - 7.2 meters, on a concrete revetment base, covered by solid hydraulic masonry. Built between 1914 and 1923, this quay was, at the time, a significant intervention towards the commercial use of the port.

The next step was the construction of Dock nr. 1, taking advantage of the old riverbed and banks of River Leça, which was diverted by a canal to outside the dock area, since this would be a dry construction. After a first failed attempt, a new tender for the work occurred in 1931, with a project by the then called *APDL – Administração dos Portos do Douro-Leixões*, in order to perform three groups of works:

1. Construction of a mole outside the harbor, of about 1000 meters long, in order to guard against sea waves in the port basin (where a few shipwrecks had occurred);
2. Construction of dock nr. 1 with 1000 meters mooring and supplementary works (diverting river Leça, sealing off the quay areas and the construction of surrounding roads);
3. Dredging and breaking rock in order to generally deepen the port. The outside mole, awarded to a Dutch firm, was the most complicated, breaking down during construction, for which reason its structure was subject to an extensive study by engineer Duarte Abecasis, and was only completed in 1945.

These works were included in the investments within the National "port plan" of 1929, promoted by the National Dictatorship Government, and was inaugurated in 1940 (on the occasion of its bicentennial anniversary).

The pressure of increased traffic following World War II entailed the development of more works in order to continue the Leixões plan. The preparatory work for the First Development Plan, when Portugal was already waiting to enter EFTA, prompted a review of the previous project and the proposal of a new configuration. It organized a new port plan, the 1955 plan, authored by Engineer-Director Henry Schreck. It was submitted to the government under the title "Enlargement of the Commercial Port of Leixões – General Plan." It established a regular plan for the enlargement of the port, which had to be performed during the 1st Stage; and a project for the acquisition of land. He projected the remaining interior docks, proposing a new type of drawbridge crossing over docks 1 and

2 as well as the flyover further inland (Via Rápida) over the location of dock 4, and planning new features. The "Schreck plan" was the basis for the current configuration of the port, and the construction of these docks lasted until the 1980s, although some of the planned areas (bulk cargo, maintenance and repairs …) were later adapted with quays for containers and ro-ro unloading docks, according to new demands in port traffic.

Figure 4. Construction of Dock 1 – 1936
Source: Port of Leixões Archive

In the short term, for the 1st stage of the enlargement works, awarded to SOMEC, came the construction of dock nr. 2 and accesses (channel crossing with dock nr. 1, the drawbridge, inaugurated in 1959, the Via Rápida flyover, surrounding avenues, the preparation of the mooring quay), which, due to its width, turned into a rotation basin for larger vessels. Also built dry, the works on dock nr. 2, which began in 1956, were complex, from the excavations to the structure of the quays, the drawbridge, the flyover and also due to the work of dislocation of water, electricity and telephone facilities between Matosinhos and Leça. The North quay started to operate in 1967.

Already under the context of the Second Development Plan (1959-1964), segments of works that had been started beforehand were continued: equipping the quay on the South bank of dock 2; a new section of the North quay of dock 2, the development of railway transportation, mooring for tankers, new buildings for the port authority and the sardine fishing harbor.

The fishing harbor, whose construction was initiated in 1959, emerged as an emblematic project, given the importance of sardine fishing and local canning industry, though the fish was unloaded on the beach, under extremely poor conditions, until the 1960s. For a long time planned for outside the port, in the area adjacent to Castelo do Queijo, the fishing harbor ended up inside the port, between dock nr. 1 and the South mole at the port entrance, in a project which covered mooring as well as the transfer of cargo. Support structures consisted of three bridge-quays, with a total mooring length of 1740 m, where 72 trawlers

could unload simultaneously, and the fish be transported by a tow truck system. Operational since 1963, Leixões, which had long been the largest sardine-fishing harbor at the international level, in terms of quantity, gained better conditions at every level.

Another significant work took place earlier in the outer moles: the oil tanker terminal (project by Enarco) in order to supply the refinery in Leça da Palmeira, built in the 1960s, by means of oil pipelines. For this purpose, the decision was taken to use the mole outside the harbor, built in the 1930s, at that time in order to alleviate the problems with waves and currents at the entrance to the harbor. Now, the height of the mole was increased to + 15 meters (Z.H.). The new mole was protected with a 40-ton armored structure of tetrapods and a concrete superstructure. These works finally managed to succeed in calming waters inside the port, besides introducing another structural asset that allowed the unloading of tankers, through an oil pipeline to the refinery, with 3 piers and connected facilities, which were inaugurated in 1969.

Figure 5. Leixões Drawbridge – 2008
Source: Photograph by João Ferrand

Based on a proposal dating back to 1973, the step to dock nr. 4 was assigned to *Construções Técnicas, SARL* on 4/10/1974, though works were only to begin, at an informal level, in late June of the following year, already within the new democratic policy framework. The North quay, reaching from the Via Rápida flyover to the top of dock nr. 2, was 503 meters long, thus creating a continuous moorage length of 1200 meters. This dock was destined for general cargo and solid bulk, with silos for grain later built nearby. The South quay was 544 meters long, and the dock 120 meters wide, with a wet area of 6.5 hectares. This quay, due to increasing containerization, was later turned into a large container terminal, complementing the smaller area that had been provided for this purpose. The construction work was awarded to SOMEC on April 16, 1974 at the Northern end of dock nr. 1. The new quay for containers in dock nr. 4 began to operate in 1989, and was subject to recent works in order to take full advantage of its potential.

Marked by the complete use of the inside space, the port of Leixões specialized the different sections of the port, and inaugurated in 1992 a leisure marina, responding to intense demand that had existed for a long time.

During the 1990s, the administration of the port of Leixoes developed a General Land Use and Development Plan. Its implementation allowed the reorganization of services and expansion within the port limits, improving some assets (fuels, containers, bulk, ro-ro), the rehabilitation of buildings and interior areas, and high investment in external and internal accessibility (notably the Port Ring Road, inaugurated in 2001). Several projects submitted for EU funding and other works above referred to were based on this plan.

Figure 6. Port of Leixões 2009
Source: Photograph by João Ferrand

The Port of Aveiro

Historically important as a natural lagoon harbor, and a starting point for significant trade in fish and salt, the port of Aveiro suffered for a long time from the consequences of the displacement of the bar to the South. The formation of a shoal almost made it disappear by the end of the eighteenth century. Displacing and setting a new bar was a later challenge, worked on by engineers such as Reinaldo Oudinot and Luís Gomes de Carvalho (renowned for their connection to the bar of the Douro), who envisaged the so-called "South mole" (later "central mole"), raised between 1802 and 1808 and later rebuilt with modifications. The main problems, however, remained unsolved, worsening with the changes in shape and size of vessels. It is only with the *Estado Novo*, through the action of the *Junta Autónoma da Ria e Barra de Aveiro*, that an initial project was planned, by engineer John Von Hafe, in 1927. His project to improve the bar consisted in a levee against currents, a riverside levee and a North mole. This project, with a few modifications, was executed between 1932 and 1936, resulting in improvements in water depth and a decrease in the variation of its position at sea, but this was still insufficient. A subsequent project took place between 1947 and 1958. It involved two moles settled offshore (an extension of 710 meters of the North mole, another mole south of the Lighthouse) and was implemented by engineer Duarte Abecasis, when he was Managing Director of Hydraulic Services. These works,

inaugurated in 1959, allowed the setting of the port along the main navigation channel between Barra and the city of Aveiro, over a distance of 8 km. The port structure, inside the Ria de Aveiro, was then organized into four sections:

- The coastal fishing harbor, located near the city of Aveiro, next to the Pyramids;
- The commercial port, between the Pyramids and the Gafanha bridge over the Ílhavo channel;
- The cod fishing harbor, which, since 1903, was located in Gafanha da Nazaré (the codfish fleet amounted to a few dozen vessels);
- The industrial port, on the Mó do Meio island.

Figure 7. Port of Aveiro - Oudinot garden
Source: Photograph by João Ferrand

Figure 8. Porto of Aveiro 2008
Source: Port of Aveiro Archive

The engineering works carried out in the port allowed a gradual increase in traffic. The construction of moles extending seawards was, in fact, the keystone intervention in the port, because they created the foundations necessary to achieve depth, stability and organization of the canal. Other operational structures appeared afterwards, from the construction of docks, the organization of spaces, warehouses and other equipment for loading and unloading, not to mention access roads to the port. These conditions resulted in a greater variety of cargoes, with a gradual increase of industrial products, closely related to the creation of an industrial zone in the region (most relevantly, the chemical industry).

In the 1980s, due to the General Plan of the Port of Aveiro, prepared for the Ports Directorate-General, new port facilities began to be built in Forte da Barra, in the district of Ílhavo. At that time a 500 meters long quay was built with a depth of - 8 meters (Z.H.), later extended by another 150 meters. Important works regarding hydraulic adjustment were also performed, with the construction of dikes and deepening of channels, in order to provide greater stability for maritime access. The North mole was extended, now with a length of 1 200 m, so as to improve the anchorage conditions after crossing the bar.

In the 1990's, a new Coastal Fishing Harbor was inaugurated, with a loading dock and support facility, 500 meters and 185 meters long, respectively, two staked piers for moorage, the fish market, warehouses for equipment and for traders.

The Port of Lisbon

The Port of Lisbon, based on its natural conditions, has become the Portuguese front in the great Atlantic routes, in what concerns both cargo and passengers, undergoing successive projects and works. It takes advantage of the broad Tagus estuary, which extends on 50 km, with a large interior space, a width that varies between 2 and 14 km and a wet area of 32 500 hectares, featuring the Mar de Palha, and including the banks of 11 municipalities. It is worth mentioning that the official limits of the port are, downstream, the lighthouses of S. Julião da Barra and Bugio and, upstream, the bridge over the river Tagus in Vila Franca de Xira.

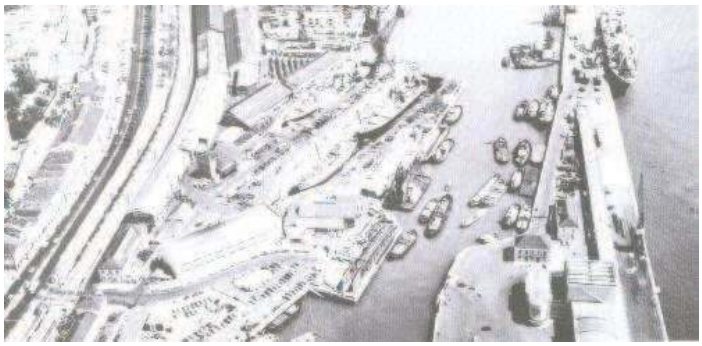

Figure 9. Naval Shipyards in 1976
Source: LISNAVE Photographic Archive – Photograph by Penaguião & Burnay

The first modernizing operations (quay of Terreiro do Paço, Paço d'Arcos dock and some lighthouses) date back to the period of the Marquis of Pombal. It is only in 1871 that a commission was appointed to prepare a "General plan of the works that should be undertaken on the banks of the Tagus between Beato and Torre de Belem, in order to improve the Port of Lisbon and the aggrandizement of the city," which, submitted in 1886, served as the basis for the works awarded to the French contractor Hersent that started in Alcantara, on October 31, 1887.

On August 24, 1895, a public invitation to tender for new projects was opened, as a result of which the engineers João Joaquim de Matos Loureiro and Adolfo carried out a series of subsequent works. The contractor Hersent, under his second contract, was granted the operation concession for 10 years, until 1907. After that time, the Administration of the Port of Lisbon was created, as an autonomous entity, in order to guarantee the State's administration of the port. It was an innovative management model that was later to serve as a model for other ports. This second phase of works mainly involved the construction of several kilometers of quays and ancillary works (slopes, embankments), warehouses, dry dock and stations for the various warehouses.

In 1921, the port of Lisbon provided a length of 6 584 linear meters of moorage quays, an area of about 80 000 m² filled with warehouses and shelters and more than 50 electric, hydraulic and steam cranes. Especially relevant during these early works are the tidal docks of Bom Sucesso, Belém, Santo Amaro, Alcantara, Alfândega and Terreiro do Trigo, as well as two dry docks and a slope that later would become the naval shipyard of Rocha. The dock of Alcântara, the largest and deepest, was dedicated to bigger drought vessels. Concrete began to be used in the construction of the port of Lisbon at the start of the century with the construction of the bridge-quay to the West of the Alfândega embankment and the Western mole of the Santos dock, in 1912. In 1915, it was used for two warehouses, one in the Alcântara embankment and another at the Santa Apolónia deposit.

The 1929 port plan, in conjunction with the endowments provided by Law nr. 1923, dated December 17, 1935, allowed works that resulted in the development of the so-called 3rd section (Santa Apolonia - Poço do Bispo), with new mooring quays and embankments, the commercial dock of Santos, the station at Alcântara, the fishing harbor in Pedrouços and the Poço do Bispo dock.

Figure 10. Port of Lisbon – Alcântara Container Terminal
Source: Port of Lisbon Archive

New projects in 1944 and 1946, fulfilling the Improvements Plan for the Port of Lisbon, followed up on the preceding works and led to further interventions, of several types:

1. Maritime works: Pedrouços dock, complementing the 3rd section (between Xabregas and Poço do Bispo), Olivais dock and regularization as far as Beirolas; work on the Belém and Bom Sucesso in order to adapt them to nautical sports, works between Terreiro do Paço and Santos; bridge-quays in Cabo Ruivo and Beirolas; regularizing the Paço de Arcos riverbank, the Jamor navigation canal, shelter and regularization in Alfeite, works at Trafaria, and regularization between Cacilhas and Alfeite;
2. Works and ground facilities, with roads and railways, warehouses, etc.;
3. Equipping the commercial port, with the installation of land and maritime equipment.

The construction of the passenger stations in Alcântara and Rocha Conde de Óbidos, according to the projects of Pardal Monteiro, dates back to the 1940s, two valuable examples of architecture of that period, with central halls decorated with frescoes by Almada Negreiros. Some of these works were scheduled to be completed between 1946 and 1955, and formally incorporated into the 1st Development Plan I (Law nr. 2058, dated December 29, 1952).

In the 2nd Development Plan, the following works still appeared:

- Conclusion of the 3rd section, between Xabregas and Santa Apolónia, initiated in 1931;
- Completion of the 1st section, between Terreiro do Paço and Santos, with works in the docks of Sodré, with a passenger station to be built next to the railway station, the construction of the Santos commercial dock and the setting of ferryboats for crossing the river;
- Adaptation of the Bom Sucesso dock to nautical sports activities (as had already happened in the Belém dock);
- Cacilhas dock, in order to form a river port and a ferryboat station, integrating it within the improvements plan for Arsenal and the Alfeite Naval base;
- Extension of roads and railways, alongside the riverside works;
- Buildings, warehouses, stations along the river, repair facilities and other buildings;
- Port equipment, both land (cranes, transporters, forklifts) and naval (tugboats, bulldozers, dredgers);
- Marking and signage within the port.

The port area of Lisbon is split into multiple units, which altogether possess 56 mooring posts. It has several maritime stations for long-distance passengers (Rocha do Conde de Óbidos, Alcântara and Santa Apolónia) and stations along the river for the intense passenger traffic between the two shores of the Tagus. There are container terminals (Alcântara, Santa Apolonia Santos), for *roll on-roll off*, for fuel, liquefied gases and numerous industrial products, shelter docks (nine altogether, two of them for leisure boats), a modern fishing dock (Pedrouços,

finally built between 1948 and 1952) and shipyards. The Naval Shipyard Rocha do Conde de Óbidos, on the right bank, and the Margueira Naval Shipyard on the South bank, were inaugurated in 1967, with three large dry docks, and expanded in 1971 with the largest dry dock in the world. It was an international benchmark for the sector, designed to accommodate tankers up to 1 million tons. It should be noted that, with the industrialization of Barreiro, the Southern area of the Tagus was already widely used through port facilities for industries that used maritime access: most relevant among these the CUF industrial complex at Barreiro, begun in 1907, the fuel terminals in Banática, in 1914, and in Porto Brandão, in 1934, National Steel in Seixal, in 1961, the fuel terminal at Trafaria, in 1968, among others.

Following the evolution of new types of cargo, the quay of Santa Apolónia was inaugurated in 1970. It was the first container terminal in the Iberian Peninsula, equipped with its own crane for loading and unloading large containers, then gradually provided with specialized cranes, made in Portugal.

1978 saw the beginning of the works on the expansion of the quay of Alcântara, 1 100 meters long, extending 80 meters over the river, floating with a concrete superstructure, which represented an important step in the modernization of the infrastructures of the port of Lisbon on its Northern bank. It was thus endowed with a pier for docking bigger draught vessels, either conventional or roll-on / roll-off. Later, in 1985, this pier went under concession to another container terminal, designed for transhipment operations.

The 1980s were also marked by the construction of port terminals for grain and food oils. The Trafaria grain terminal, one of the largest facilities of its kind in Europe with a capacity of 200 000 tons and equipped with a bridge-quay with adjacent deepwater between 14 and 17 meters, was inaugurated in 1984. Two years later, the Palencia terminal came into operation, with a capacity of 90 000 tons of soy, for the food oil plant existing at that location.

Figure 11. Port of Lisbon 2008
Source: Port of Lisbon Archive

More recently, in the 1990s, most notable were the expansion of the Santa Apolónia container terminal, whose ground area was increased by about 79 000 m² and the construction of the respective road and rail accesses, in addition to the deepening of the Alcântara container terminal by advancing the quay, consisting of a platform built with piles.

With a length bordering almost the whole city, the port of Lisbon has also been the object of works aimed at the recovery of derelict areas and/or reconversion activities, for example the urban interventions in the eastern part of the city, centered around Torre de Belém (for the Empire Exhibition of 1940) and the urbanization of the Western zone for the Lisbon EXPO 98. More recently, the reconversion of disused commercial areas, and in addition the recovery of some riverfront areas, have meant that the port is more and more open to the public in general, creating greater harmony in the relationship between city and port.

The Port of Setúbal

In the opinion of many specialists, the port of Setúbal has always been the second best port, immediately after Lisbon, with regard to natural conditions, since it has considerable depth, although irregular (the maximum vessel's draught is 9.6 m), in addition to the quality of river Sado as a waterway, allowing navigation up to 65 km upriver. Historically, this port was associated to salt, fishing (which afterwards led to a thriving canning industry) and regional agricultural products (wine, cork, oranges), to which was added, in the twentieth century, the handling of fertilizers (superphosphates), minerals and cement. More recently, in the 1960s, the export of paper pulp gained importance (Portucel), as did shipbuilding (Setenave shipyards).

With projects that, according to Adolfo Loureiro, date back to 1793, it is only in the mid-nineteenth century that a dock was built at the mouth of the old Ribeiro do Livramento – the Delpeut dock, which ended up, during nearly a century, being the only shelter for vessels in the port of Setúbal. In 1876, at the initiative of the city council, a wharf and its respective embankment were built next to the dock.

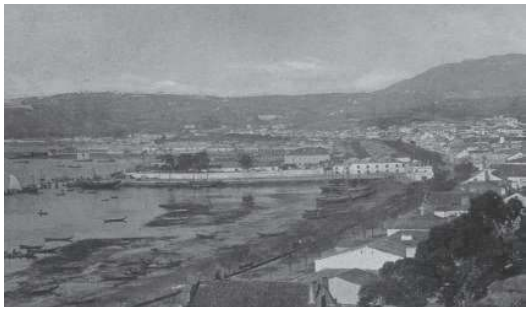

Figure 12. Port of Setúbal
Source: Port of Setúbal Archive

Figure 13. Port of Setúbal 2008
Source: Port of Setúbal Archive

Although several projects had been drafted, the port of Setúbal had to wait until 1930, and the scope of the Dictatorship port plan, to start the more relevant construction works. Interventions regularized the banks of the right side of the Sado, and created structures with specific functions: the commercial port, the fishing harbor and marina, and six stakes with a total length of 430 meters. The works were awarded to the Danish firm Hidgaart & Schultz and the dredging to the Dutch firm Van der Boch & De Vries. These interventions were based on a project approved by the Board of Public Works in 1927 and continued until 1934, improving, principally, the level of urban hygiene and quality of the port service.

In the late 1960s, the piles of the commercial wharf were replaced by a 175 meters long quay and 9.5 m deep, built on platforms. The first electric cranes were acquired at that time, replacing the traditional short-range car cranes.

Later, as a result of the industrial growth that took place in the district, the Fontaínhas terminal was gradually extended, new handling equipment was acquired and support buildings and warehouses were built. The increase in port traffic doubled over the next twenty years: from 640 000 tons in 1960 to 1 239 000 in 1980. Currently, the Fontaínhas terminal consists in a 610 meters long quay, 9.5 meters and 10.5 meters deep, with a *ro-ro* ramp at the top East side, and with an open storage area of 50 000 m^2 and a covered storage area of 3 600 m^2. The *ro-ro* ramp was completed in 1988 and was the first mooring of this kind in the country, responding to growing demand for the port by stern ramp *ro-ro* vessels.

Directly related to the increased industrialization of the area of Setúbal, especially since the 1960s, port facilities upstream are associated to companies, some of them inactive or little used. The most relevant examples are: the Propan bridge-quay; the Pirites Alentejanas pier, with a conveyor belt; the Sapec quay; the Mague quay; the Portucel quay; the Boliden quay; the Solisnor complex (ex-Setenave three dry docks and six quays for large vessels); the Eurominas quay. There are also support structures for the Setúbal-Troia ferryboats connection.

In 1992, the construction of a new lateral mooring station, 220 meters long, is associated to the AutoEuropa facility in Portugal, and a terminal was built for the export of cars produced in the factory in Palmela.

Nowadays, the port of Setúbal handles about 6 500 000 tons of commodities, and the multi-purpose terminal, the largest terminal of this kind in Portugal, is in the concluding stage. It has a dock length of 723 meters, with depths of 12.5 m (ZH), which corresponds to an adjacent embankment with a total area of 23 hectares, an essential investment in view of growing container traffic. The port of Setúbal is today one of the most important national ports in terms of volume of traffic and value and diversity of commodities handled.

The Port of Sines

Taking advantage of the shelter provided by its natural bay, and without any significant mooring infrastructures, port operations in Sines took place offshore for centuries. The Romans used the port of Sines as a supply port for passing vessels, connected to salting fish, and the port was later associated to the important coastal stronghold. In more recent times, the port was required for the shipment of cork, olives and citrus fruit produced in the region and intended primarily for the English market. However, over the years, fishing has always been the main local economic activity.

Figure 14. Port of Sines 2008
Source: Port of Sines Archive

In the late 1960s, in view of the growing international trend of using large bulk vessels (both liquid and solid), the government, as part of the development plans, considered the national alternative to an artificial port for this type of traffic, and chose Sines, mainly due to its natural conditions, with relatively well sheltered deep waters near the coast. The new port, initially geared towards the

handling of petroleum and mineral products, was to become a center for regional development, in connection to projects for various industrial undertakings aimed at a concentrated area of basic industries, within the scope of the Sines Area Development Plan. The Sines Area Office was created in 1971 (Decree-Law nr. 270/71, dated June 19) in order to implement this project. But not all the industrial undertakings originally planned came to be built, given the evolution of the international situation, highly influenced by decolonization, the oil crises and the deactivation of the steel industry. An oil refinery was installed, a petrochemical complex and a coal-fired power station, significant investments that led to other, complementary industrial units.

The initial project for the port of Sines, approved in 1972, after studying several alternative plans, planned the disappearance of the beach of Sines and the dislocation of the fishing harbor to an area to the South, making these areas available for new port infrastructures. Greatly challenged by the local community, this solution was partially revised in 1976, only to be radically changed in 1985 with the new Master Plan for the Port of Sines.

The project for the port was initially based on the construction of the West mole from the Sines Cape in a North-South direction, approximately 2 000 meters long, to protect the maneuvering and mooring basins of the petroleum and petrochemical terminals and, later, on the East mole, roughly in a East-West direction and approximately 1 100 meters long, which would serve to protect the coal unloading terminal. After the main contract was awarded in 1973, the works began, later that same year, and in 1978 the commercial operation of the port began with the entry into service of the oil terminal. It should be noted that the Administration of the Port of Sines was created in 1977 (Decree-Law nr. 508/77), the Sines Area Office was extinguished in 1986 and the respective planning and construction services assigned to the abovementioned Administration, along with the operation of the port.

The construction and subsequent consolidation, particularly of the West Mole, due to the size reached – 2 000 meter mole and depths of – 50 meters (Z.H.), remain in history as one of the great Portuguese works of engineering and have merited the attention of international specialists in this field. In 1978 and 1979, violent storms brought down much of the outer protection of the mole, that consisted of a 42 tons cloak of dolosse, including the final section of the wall-screen. Structural failures in dolosse of that size were later acknowledged, and, for the repairs, the decision was taken to replace the cloak of dolosse by a cover of "Antifer" type 90 ton grooved cubes, better suited to withstand the severe storms that often occur.

These accidents attracted the attention of world experts in view of the expectations that had been created by the use of dolosse, turning the port of Sines into a case study for the international scientific community related to maritime hydraulics and coastal protection. Given the complex nature of products circulating in the port of Sines (espacially chemical), concerns with safety has received special attention and investment.

The port of Sines currently comprises several terminals, which include several mooring berths that are listed here in their chronological order of entry into operation:

- Oil Terminal (1978);
- Petrochemical Terminal (1981);
- Coal Unloading Terminal (1987), regarding which subsequent developments led to its use for several purposes and is now known as the Multipurpose Terminal;
- General Cargo Terminal (1993);
- Leisure Marina (1995);
- Deepwater terminal for container shipping, called Terminal XXI, on decision by the government in 1998, commencing construction in 2000, with entry into operation scheduled for the first quarter of 2003;
- National Natural Gas Unloading Terminal, on decision by the government in 1998, commencing construction in 2000, with entry into operation scheduled for the final quarter of 2003.

The initial plan for the Port of Sines has not remained unchanged, having been revised and expanded for new purposes. The oil crisis in 1973-1974 and the changes in maritime transport in those domains implied the need to reformulate the solutions initially adopted for the new types of maritime transport, particularly the increasing importance of containerization and the development of logistics chains. Besides, what mattered was to take advantage of the specific features of the port of Sines, with water depth above -16 meters, easily adaptable to receiving larger vessels, with good maritime access routes and flexibility for the expansion of the port and embankments. In this way, on the one hand, advantage was taken of its initial propensity towards energy (oil, coal and, now, natural gas). On the other hand, Sines strengthened its inclusion in international maritime routes with the creation of new quays at the Multipurpose Terminal and the construction of Terminal XXI for last generation container vessels, together with its location and development of areas for logistics activities. With other recently completed interventions, such as the extension of the fishing harbor quay, LPG storage or the extension of the East mole still under construction, the Natural Gas Terminal and the new road and rail accesses to the Southern area of the port, the aim is to project the port of Sines as a new generation port looking to the future. At the same time, it continues to be a support for the local industrial complex that, with the implementation of new Trans-European transport networks, will provide it with renewed importance at both regional and national level.

Among the Portuguese ports, Sines it the port that handles the largest tonnage of cargo since 1981, reaching today above 20 million tons per year. With these new developments, the port of Sines will be able to enhance its national contribution and to assert itself as a port of reference in the European and international context.

Figure 15. Port of Sines - Terminal XXI
Source: Port of Sines Archive

Conclusions

Portugal's coastal situation provided a set of natural conditions propitious for the use of ports, and history has selected the most adequate according to the conditions of time and the economic dynamics of the hinterland.

The constraints of the twentieth century, continuing the development of the nineteenth-century, decisively imposed a selection process that involved politics. The central government was forced to assume obligations and started funding improvement works and adapting to the requirements of the operations that emerged meanwhile. But a port is not only a physical infrastructure; it is also a production unit, a link in the chain of production. Understanding this fact was crucial in the evolution of ports during the twentieth century, all the more so because in view of infrastructures, a port is costly to build and maintain, requiring sustained and renewed engineering works, as well as flexibility in their management in order to understand evolution and adapt to change.

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